Space Weather Technical Forecast

Issued on Wednesday, 03 January 2024 at 01:23 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-flares likely from AR3536, with a slight chance of X-flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with one M-flare observed, peaking at M1.1 at 02/1830 from AR3536 in the northeast. This continues to be the main region of note, although remains small with some degree of weakening having occurred. This can be seen with the main spot separating into distinct penumbral regions, and subsequently losing its delta configuration. This remains a complex region however, with a number of small spots of varying polarities following this main spot. There are a total of four sunspot regions on the disc, with the other three all smaller and simpler, with no significant growth observed.

A number of CMEs were visible in imagery, however these have all been assessed as being off the Earth-Sun line with no Earth-directed CMEs occurring.

Solar Wind / Geomagnetic Activity: Solar winds were indicative of a weak fast wind from CH86/-. Speeds were slightly elevated at 400-450 km/s, and density remained at or near average. Interplanetary Magnetic Field (IMF), Bt, has declined from initially moderate with a peak of 12nT to be mainly weak at 5-8nT. The north-south component, Bz was initially moderate southward, with minimum -10nT, but soon became mainly positive (northward), peaking +7nT. Phi angle was generally negative (towards the Sun). Geomagnetic activity was Quiet to Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was mostly at background, though a minor response post X5.0 flare was observed and is ongoing. A peak of 4.6pfu at 02/0030 UTC was observed, before a decline with the fast wind onset, before another rising trend has subsequently been observed to be 4.8pfu by 03/0000 UTC. GOES16 high energy (greater than 2MeV) electron flux ranged was mainly at background. The 24-hour fluence was below Active throughout. The 03/0000 UTC observation was 1.31e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Region AR3536 in the northeast dominates the flare risk during the forecast period. Generally Moderate activity is expected, with further M-flares likely and a slight chance of further X-flares.

Solar Wind / Geomagnetic Activity: The X5.0 flare appears likely to have missed, however there remains a chance of a glancing arrival early on day 1 (03 Jan). Further weak CMEs, from a C-flare on 30 Dec, a filament eruption on 31 Dec and a corona sourced CME also on 30 Dec also have the potential to give a glancing enhancement on days 1-2 (03-04 Jan), however any influence from these is expected to be minimal. Current fast winds from CH86 are expected to continue days 1-2 (03-04 Jan), before easing to background days 3-4 (05-06 Jan). No other enhancements are forecast. Quiet geomagnetic activity is expected for much of the period, with a decreasing chance of isolated Unsettled spells. Any CME influence will bring a chance of Active intervals, with a very slight chance of G1 Minor Storms, mainly if any influence of the X5.0

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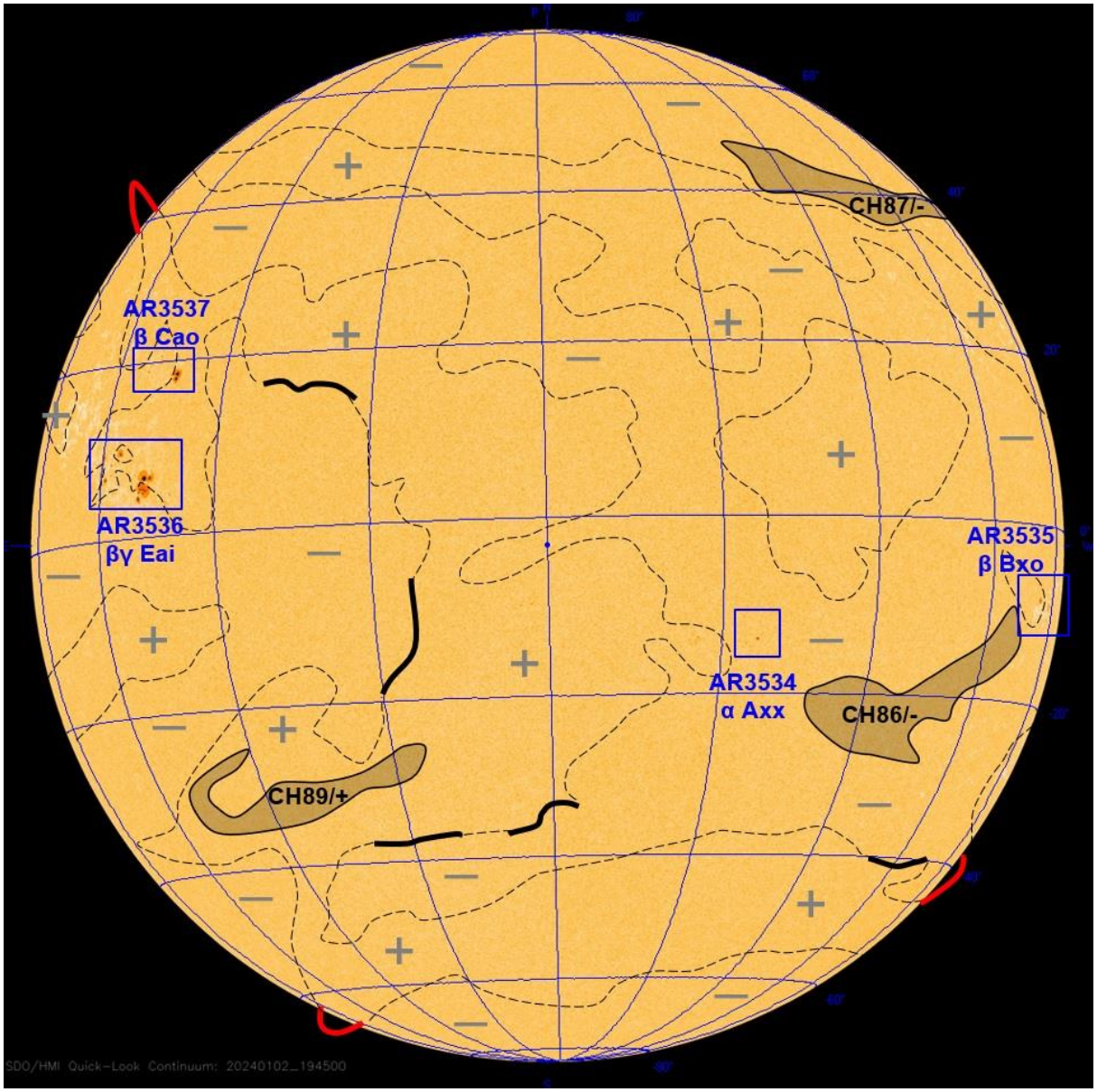
CME is observed early day 1 (03 Jan).

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain below S1 storm levels, however there remains a slight chance of breaching the S1 threshold, mainly day 1 (03 Jan) due to the current rising trend to proton flux, or later in the period when AR3536 moves into a more central disc position. GOES16 high energy electron flux is likely to remain near background, perhaps briefly rising to Moderate later in the period, with the associated fluence remaining below the Active level.

Figure 1. Solar Analysis Valid 02/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

The CME from the X5.0 flare has now likely missed, passing east of (behind) Earth on 02 Jan, although it is not impossible that a very late glancing influence may occur early on day 1 (03 Jan). This would give a slight chance of Active to G1 Minor Storms, if this was to occur

There are a number of other weak CMEs which may have an influence on the observed solar wind at Earth through day 1 and into day 2 (03-04 Jan), including a slow C-flare on 30 Dec, a filament eruption off the northwest on 31 Dec and a high corona reconfiguration off the south disc on 31 Dec. These are all low confidence however, and likely to be only very minor increases above the ongoing fast wind from CH86/-, but may give a further risk of Active intervals.

Otherwise, fast winds from CH86/-, with speeds 400-450km/s are expected to continue day 1 and day 2 (03-04 Jan). No other solar wind enhancements are then expected, with the fast wind expected to gradually ease towards background days 3 and 4 (05-06 Jan).

Quiet geomagnetic activity is expected for much of the period, with a decreasing chance of isolated Unsettled spells. Any CME influence will bring a chance of Active intervals, with a very slight chance of G1 Minor Storms, mainly if any influence of the X5.0 CME is observed early day 1 (03 Jan).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	15	5	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
01/0050	Partial Shock	X5.0 AR3536	E limb	1250 km/s	Missing, chance early 03 Jan	Adjusted analysis based on lack of arrival
30/2000	Nil	C2.6 AR3534	SE	320 km/s	03- early 04Jan	Weak. Slight glance possible
31/0817	Nil	S-disc corona	S	440 km/s	03-early 04Jan	Likely miss Slight glance possible
31//1433	Nil	Filament	NW	907 km/s	03-early 04Jan	Likely miss Slight glance possible

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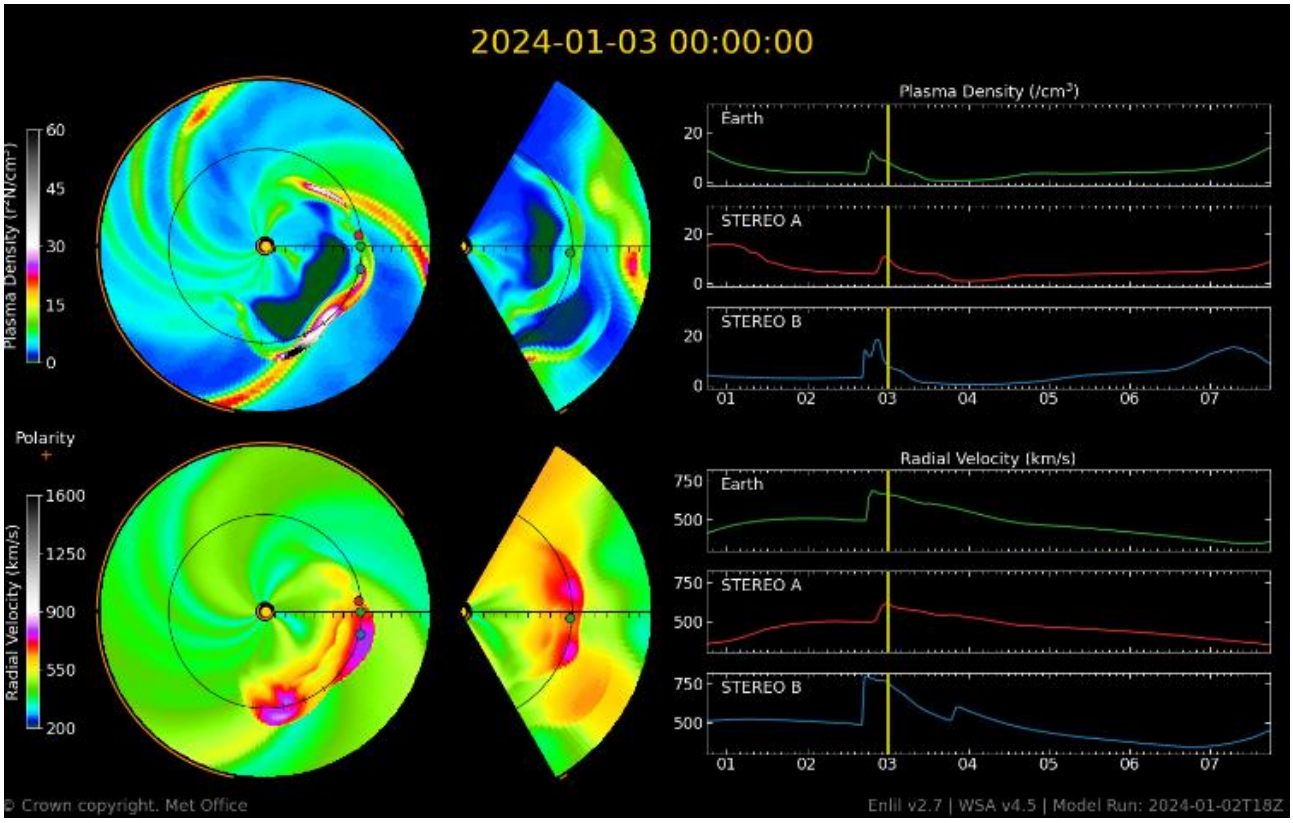
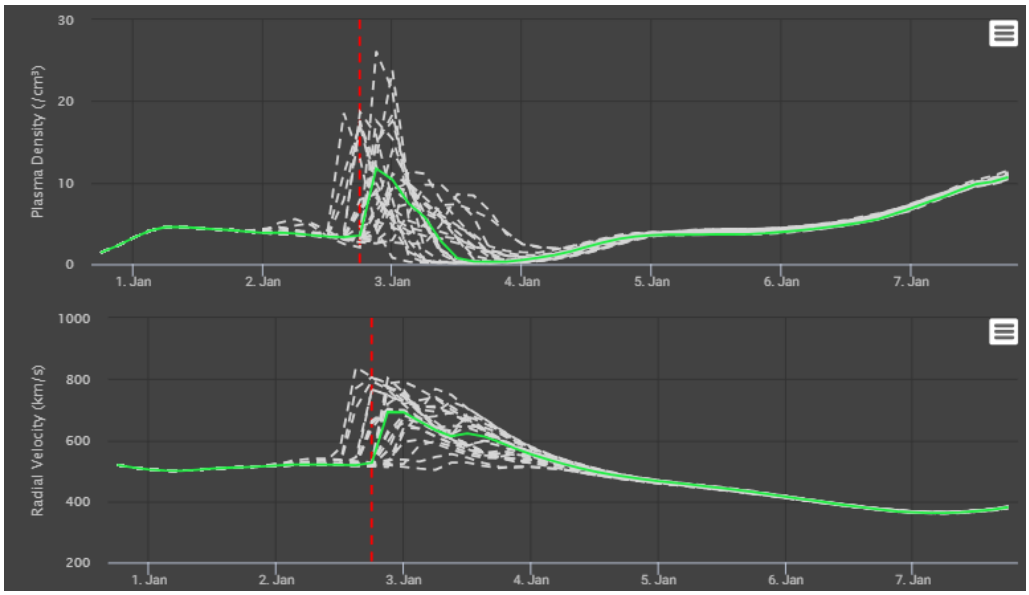
Figure 2: Adjusted enlil showing glancing arrival of CME, which has not been observed. Ensemble below, showing later arrival still possible.





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Radio Blackouts - X-Ray Flares:

Moderate activity is likely to continue with an ongoing chance of M-flares from AR3536 and a slight chance of further X-class flares.

There are four sunspot regions on the disc, with AR3536 in the northeast remaining the main sunspot of interest. This region produced an X5.0 flare on 31 Dec, and a number of smaller M-class flares since. In the last 24 hours however, there has been a suggestion of a weakening trend with the main spot of the group splitting into two separate regions of different polarity, and the region losing its delta configuration. However some complexity persists within the group, with mixed polarities in both the leader and trailer areas, and some bright looping evident within its magnetic canopy on SDO imagery. This means that despite the relatively small and ragged appearance of the spot, there remains the potential for M-flares, and a slight chance of further X-flares from this region.

The other regions are mainly smaller and simper, with AR3534 now largely decayed, and regenerated AR3535 soon rotating off the west limb. However, AR3537 to the north of AR3536 still has some potential for further growth.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3a: GOES-16/19 X/fares

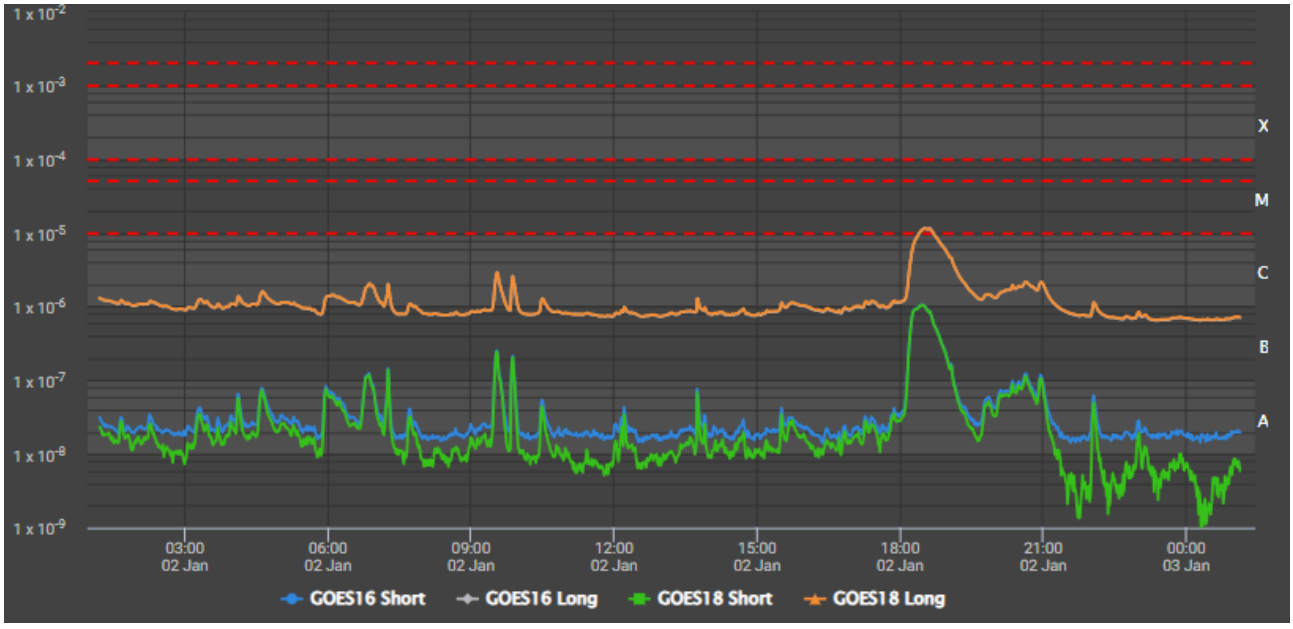

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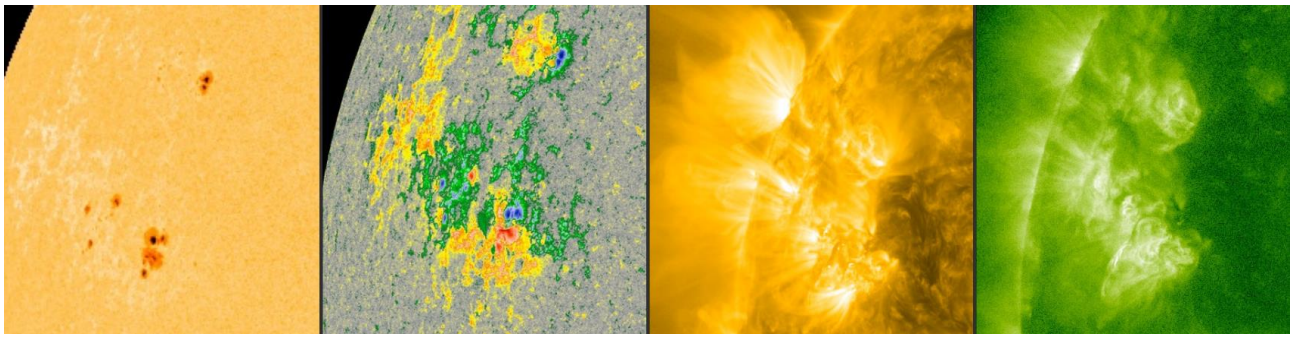
Figure 3b: SDO intensitygram, magnetogram, aia-171, aia-94 of AR3936 (bottom) and AR3937 (top)

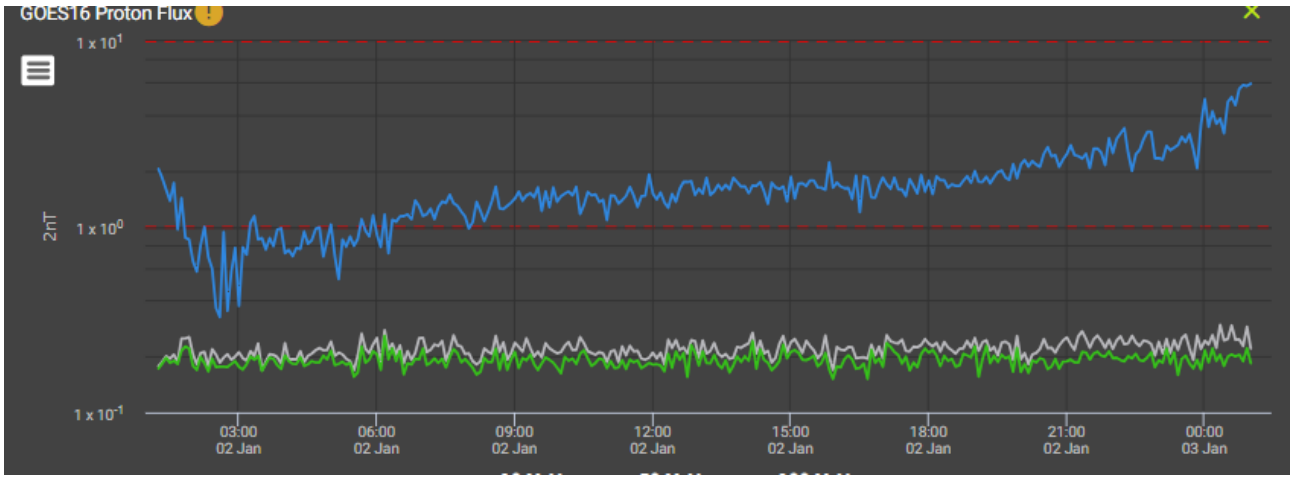


Solar Radiation Storms - (High Energy Protons):

GOES16 high energy (greater than 10MeV) proton flux remains just above background, but below the S1 level, due to the X5.0 flare from AR3536 on 31 Dec. Any further significant flares, primarily from this region, will bring a slight chance of further increases in the observed proton flux. This gives a slight chance of reaching the S1 Minor Storm level, perhaps slightly increasing in risk later in the period as the region moves further west on the disc and into a more central location.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	5	5	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-16 >10MeV, >50MeV and >100 MeV Proton flux



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES-16 continues to persist at mostly background levels. The fast wind arrival on 02 Jan was weaker than originally expected, with only minimal geomagnetic activity observed. Furthermore, no significant CME enhancement has been observed, with the X5.0 CME now looking more likely to have missed. There are further weak CME arrivals possible on day 1-2 (03-04 Jan) however these are unlikely to impact the forecast. Consequently, mainly background flux is expected to continue with a chance of reaching Moderate during periods of diurnal maximum.

The associated 24 hour fluence is forecast to persist at background, although a rising trend is likely day 3-4 (05-06 Jan), as solar winds ease. This is supported by REFM which is currently giving good guidance, however this may chance if any CME arrival occurs.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^{8}$	No	1	1	1	1
Very Active	≥ 2 MeV ≥ $1x10^{9}$	No	1	1	1	1

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